

## IN THE CLAIMS:

1. (currently amended) A precoder for generating a mapped constellation signal, from an input signal, comprising:

a feedback filter that generates a feedback signal as a function of the mapped constellation signal, and

a processing element ~~a discrete modulo adder~~ that generates the mapped constellation signal from the input signal and the feedback signal, the processing element ~~discrete modulo adder~~ utilizing an index to a ~~the~~ constellation of levels chosen for the precoder, wherein the constellation of levels includes a basic constellation of levels and a set of levels outside the basic constellation of levels, such that the amplitude of the mapped constellation signal is limited.

2. (currently amended) The precoder according to claim 1, wherein the processing element ~~discrete modulo adder~~ comprises:

an adder that adds together the feedback signal and the input signal to generate a partial result, and

a mapper that generates the mapped constellation signal by mapping a partial result outside a ~~the~~ basic constellation of levels onto the basic constellation of levels as a function of the index to the constellation of levels for the precoder.

3. (original) The precoder according to claim 1, wherein the feedback filter includes a delay element and a weighting element such that the feedback filter multiplies a delayed version of the mapped constellation signal by the weighting element to generate the feedback signal.

4. (original) The precoder according to claim 1, wherein the feedback filter is based upon a model of the impulse response of a communication channel.

5. (currently amended) The precoder according to claim 2, wherein the mapper further comprises:

a table identifying a the basic constellation of levels and a mapping from the set of levels outside the basic constellation to levels inside the basic constellation.

6. (currently amended) The precoder according to claim 1 5, wherein each of the levels outside the basic constellation of levels is in the table are mapped onto only one level inside the basic constellation in the table.

7. (original) The precoder according to claim 5, further comprising:

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a table having a constellation index basic\_const, where basic\_const goes from 1 to k, associated with each of a plurality of levels inside the basic constellation, and having a constellation index positive\_const, where positive\_const goes from k+1 to m, associated with a plurality of levels outside the basic constellation.

8. (original) The precoder according to claim 7, wherein each of the plurality of levels outside the basic constellation index are mapped onto a level inside the basic constellation according to the equation:

index positive\_const  $\rightarrow$  positive\_const - (2\*k); while positive\_const > m-k; and

index positive\_const  $\rightarrow$  positive\_const - (2\*k) - 1; while positive\_const  $\leq$  m-k;

wherein  $\rightarrow$  identifies the mapping function.

9. (original) The precoder according to claim 5, further comprising:

a table having a constellation index basic\_const, where basic\_const goes from -1 to -k, associated with each of a plurality of levels inside the basic constellation, and having a constellation

index  $\text{negative\_const}$ , where  $\text{negative\_const}$  goes from  $-k-1$  to  $-m$ , associated with a plurality of levels outside the basic constellation.

10. (original) The precoder according to claim 9, wherein each of the plurality of levels outside the basic constellation index are mapped onto a level inside the basic constellation according to the equation:

$\text{index } \text{negative\_const} \rightarrow \text{negative\_const} + (2*k); \text{ while } \text{negative\_const} < -(m-k); \text{ and}$

$\text{index } \text{negative\_const} \rightarrow \text{negative\_const} + (2*k)+1; \text{ while } \text{negative\_const} \geq -(m-k);$

wherein  $\rightarrow$  identifies the mapping function.

11. (original) The precoder according to claim 7, wherein the mapper further comprises a comparator for comparing the partial result with the levels in the table.

12. (original) The precoder according to claim 11, wherein the comparator identifies the level closest to the partial result.

13. (original) The precoder according to claim 12, wherein the mapper further includes an output block that generates a mapped constellation signal equal to a level inside the basic constellation, if the identified level in the table closest to the partial result is inside the basic constellation.

14. (original) The precoder according to claim 12, wherein the output block includes a summer for adding the partial result and a mapping distance signal, wherein the mapping distance signal equals the distance between the index  $\text{basic\_const}$ , associate with the basic constellation level of the input signal, and the index  $\text{positive\_const}$ , associated with a level outside the basic constellation.

15. (original) The precoder according to claim 1, further comprising a digital to analog converter that generates an analog output signal based upon the mapped constellation signal.

16. (original) The precoder according to claim 15, further comprising a transformer for operably coupling the digital to analog converter to an analog subscriber loop.

17. (currently amended) The precoder according to claim 1 ~~15~~, wherein successive levels in the basic constellation of levels are separated by a distance D1, and wherein a plurality of successive levels outside the basic constellation are separated by a distance D2 such that D1 differs from D2.

18. (currently amended) A precoder for an analog modem, the precoder comprising:

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a processing element ~~a discrete modulo adder~~ that generates a mapped constellation signal as a function of a ~~an~~ feedback signal and an input signal to the precoder, the processing element ~~discrete modulo adder~~ including:

an adder that adds together the feedback signal and the input signal to generate a partial result,

a table identifying a basic constellation of levels and levels outside the basic constellation, wherein the levels outside the basic constellation are mapped onto levels inside the basic constellation as a function of an index associated with each level in the table,

~~a comparator for comparing the partial result with the levels in the table,~~

an output block that generates a mapped constellation signal equal to a level inside the basic constellation by mapping a partial result outside the basic constellation of levels onto a level inside the basic constellation of levels, and

a feedback filter that generates the feedback signal as a function of the mapped constellation signal output by the processing element ~~discrete modulo adder~~.

19. (original) The precoder according to claim 18, wherein each of the levels outside the basic constellation in the table are mapped onto only one level inside the basic constellation in the table.

20. (original) The precoder according to claim 18, further comprising  
a table having a constellation index `basic_const`, where `basic_const` goes from 1 to `k`, associated with each of a plurality of levels inside the basic constellation, and having a constellation index `positive_const`, where `positive_const` goes from `k+1` to `m`, associated with a plurality of levels outside the basic constellation.

21. (original) The precoder according to claim 20, wherein each of the plurality of levels outside the basic constellation index are mapped onto a level inside the basic constellation according to the equation:

$\text{index positive\_const} \rightarrow \text{positive\_const} \_ (2*k); \text{ while } \text{positive\_const} > m-k; \text{ and}$

$\text{index positive\_const} \rightarrow \text{positive\_const} - (2*k)-1; \text{ while } \text{positive\_const} \leq m-k;$

wherein  $\rightarrow$  identifies the mapping function.

22. (original) The precoder according to claim 18, further comprising:

a table having a constellation index `basic_const`, where `basic_const` goes from -1 to -`k`, associated with each of a plurality of levels inside the basic constellation, and having a constellation index `negative_const`, where `negative_const` goes from -`k-1` to -`m`, associated with a plurality of levels outside the basic constellation.

23. (original) The precoder according to claim 22, wherein each of the plurality of levels outside the basic constellation index are mapped onto a level inside the basic constellation according to the equation:

index negative\_const  $\rightarrow$  negative\_const + (2\*k); while negative\_const  $\leq$  -(m-k); and

index negative\_const  $\rightarrow$  negative\_const + (2\*k) + 1; while negative\_const  $\geq$  -(m-k);

wherein  $\rightarrow$  identifies the mapping function.

24. (original) The precoder according to claim 20, wherein the output block includes a summer for adding the partial result and a mapping distance signal, wherein the mapping distance signal equals the distance between the index basic\_const, associated with the basic constellation level of the input signal, and the index positive\_const, associated with a level outside the basic constellation.

25. (currently amended) A method of precoding an input signal to generate a mapped constellation signal, comprising:

generating a feedback signal from the mapped constellation signal, and

performing ~~a discrete modulo~~ an operation on the feedback signal and the input signal based upon an index to ~~a~~ the constellation of levels chosen for the precoder, wherein the constellation of levels includes a basic constellation of levels and a set of levels outside the basic constellation of levels, such that an ~~the~~ amplitude of the mapped constellation signal is limited.

26. (currently amended) The method of precoding according to claim 25, wherein the step of performing ~~a discrete modulo~~ the operation includes:

adding together the input signal and the feedback signal to generate a partial result,

determining whether the generated partial result is contained within the basic constellation of levels, and

generating the mapped constellation signal by mapping a partial result outside the basic constellation of levels onto a level inside the basic constellation of levels as a function of the index to the constellation of levels for the precoder.

27. (original) The method according to claim 25, wherein the step of generating the feedback signal further includes multiplying a delayed version of the mapped constellation signal by a weighting element to generate the feedback signal.

28. (currently amended) The method according to claim 26, wherein the determining step further includes comparing the generated partial result with a table identifying a the basic constellation of levels and a plurality of levels outside the basic constellation.

29. (original) The method according to claim 28, further including generating a mapped constellation signal equal to the partial result if the partial result is inside the basic constellation of levels.

30. (currently amended) The method according to claim 28, further including the step of determining whether the partial result is less than the minimum level of the basic constellation or whether the partial result is greater than a ~~the~~ maximum level of the basic constellation.

31. (original) The method according to claim 30, further including the step of determining a mapping distance  $p_j$  when the partial result is less than the minimum level of the basic constellation, the mapping distance  $p_j$  being equal to a distance between an index basic\_const, associated with the basic constellation level of the input signal, and an index positive\_const, associated with a level outside the basic constellation..

32. (original) The method according to claim 31, wherein the index positive\_const is an index to a level that maps onto the basic constellation level of the input signal, and wherein index positive\_const is an index to a level in a positive constellation of levels that includes those levels greater than the maximum in the basic constellation.

33. (original) The method according to claim 32, further including the step of obtaining the index positive\_const from a table.

34. (original) The method according to claim 31, further including the step of generating a mapped constellation signal by adding together the partial result and the mapping distance  $p_j$ .

35. (original) The method according to claim 30, further including the step of determining a mapping distance  $n_j$ , when the partial result is greater than the maximum level of the basic constellation, the mapping distance  $n_j$  being equal to a distance between an index basic\_const, associated with the basic constellation level of the input signal, and an index negative\_const, associated with a level outside the basic constellation.

36. (original) The method according to claim 35, wherein the index negative\_const is an index to a level that maps onto the basic constellation level of the input signal, and wherein index negative\_const is an index to a level in a negative constellation of levels that includes those levels less than the minimum level in the basic constellation.

37. (original) The method according to claim 36, further including the step of obtaining the index negative\_const from a table.

38. (original) The method according to claim 35, further including the step of generating a mapped constellation signal by adding together the partial result and the mapping distance  $n_j$ .



39. (currently amended) A computer-readable medium having stored thereon a plurality of instructions, the plurality of instructions including instructions that when executed by a processor cause the processor to implement a method of precoding an input signal to generate a mapped constellation signal, the method comprising:

generating a feedback signal from the mapped constellation signal, and

performing ~~a discrete modulo~~ an operation on the feedback signal and the input signal based upon an index to ~~a the~~ constellation of levels chosen for the precoder, wherein the constellation of levels includes a basic constellation of levels and a set of levels outside the basic constellation of levels, such that an ~~the~~ amplitude of the mapped constellation signal is limited.

40. (currently amended) The computer-readable medium of claim 39, wherein the step of performing ~~a discrete modulo~~ the operation further includes:

adding together the input signal and the feedback signal to generate a partial result,

determining whether the generated partial result is contained within a the basic constellation of levels, and

generating the mapped constellation signal by mapping a partial result outside the basic constellation of levels onto a level inside the basic constellation of levels.

41. (new) The precoder according to claim 1 wherein the amplitude of the mapped constellation signal is limited to the basic constellation of levels.

42. (new) The precoder according to claim 18 wherein a first distance between successive levels in the basic constellation of levels differs from a second distance between successive levels outside the basic constellation of levels.

43. (new) The method according to claim 25 wherein the step of performing includes limiting the amplitude of the mapped constellation signal by the basic constellation of levels.

44. (new) The method according to claim 25 wherein a first distance between successive levels in the basic constellation of levels differs from a second distance between successive levels outside the basic constellation of levels.

45. (new) The method according to claim 25 wherein the step of performing includes mapping each level outside the basic constellation of levels onto only one level inside the basic constellation of levels.

46. (new) The computer-readable medium of claim 39 wherein the amplitude of the mapped constellation signal is limited to the basic constellation of levels.

47. (new) The computer-readable medium of claim 39 wherein a first distance between successive levels in the basic constellation of levels differs from a second distance between successive levels outside the basic constellation of levels.

48. (new) The computer-readable medium of claim 39 wherein the step of performing includes mapping each level outside the basic constellation of levels onto only one level inside the basic constellation of levels.

49. (new) An apparatus for generating a mapped constellation signal from an input signal, comprising:

a precoder that generates the mapped constellation signal from the input signal and a feedback signal, wherein the precoder utilizes a constellation of levels that include a basic constellation of levels and a set of levels outside the basic constellation of levels, and wherein the

precoder associates an index with each of the levels in the constellation of levels such that the levels outside the basic constellation of levels can be associated with the levels inside the basic constellation of levels.

50. (new) The apparatus according to claim 49 further including a feedback filter having a delay element and a weighting element such that the feedback filter multiplies a delayed version of the mapped constellation signal by the weighting element to generate the feedback signal.

51. (new) The apparatus according to claim 49 further including a feedback filter based upon a model of an impulse response of a communication channel.

52. (new) The apparatus according to claim 49 wherein the precoder employs an adder that adds together the feedback signal and the input signal to generate a partial result and a mapper that generates the mapped constellation signal by mapping a partial result outside the basic constellation of levels onto the basic constellation of levels as a function of the index to the constellation of levels, the mapper having a table to identify the basic constellation of levels and associate levels outside the basic constellation to levels inside the basic constellation.

53. (new) The apparatus according to claim 49 wherein each of the levels outside the basic constellation are only associated with one level inside the basic constellation.

54. (new) The apparatus according to claim 49 further comprising a table that identifies the basic constellation of levels, wherein the table has a constellation index `basic_const`, where `basic_const` goes from 1 to `k`, associated with each of a plurality of levels inside the basic constellation, and wherein the precoder has a constellation index `positive_const`, where `positive_const` goes from `k+1` to `m`, associated with a plurality of levels outside the basic constellation.

55. (new) The apparatus according to claim 54 wherein the mapper maps each of the plurality of levels outside the basic constellation index onto a level inside the basic constellation according to the equation:

index positive\_const  $\rightarrow$  positive\_const - (2\*k); while positive\_const > m-k; and

index positive\_const  $\rightarrow$  positive\_const - (2\*k) - 1; while positive\_const  $\leq$  m-k;

wherein  $\rightarrow$  identifies the mapping function.

56. (new) The apparatus according to claim 49 further comprising a table that identifies the basic constellation of levels, wherein the table has a constellation index basic\_const, where basic\_const goes from -1 to -k, associated with each of a plurality of levels inside the basic constellation, and wherein the precoder has a constellation index negative\_const, where negative\_const goes from -k-1 to -m, associated with a plurality of levels outside the basic constellation.

57. (new) The apparatus according to claim 56 wherein the mapper maps each of the plurality of levels outside the basic constellation index onto a level inside the basic constellation according to the equation:

index negative\_const  $\rightarrow$  negative\_const + (2\*k); while negative\_const < -(m-k); and

index negative\_const  $\rightarrow$  negative\_const + (2\*k) + 1; while negative\_const  $\geq$  -(m-k);

wherein  $\rightarrow$  identifies the mapping function.

58. (new) The apparatus according to claim 54 wherein the mapper further comprises a comparator for comparing the partial result with the levels in the table.

59. (new) The apparatus according to claim 58 wherein the comparator identifies the level closest to the partial result.

60. (new) The apparatus according to claim 59 wherein the mapper further includes an output block that generates a mapped constellation signal equal to a level inside the basic constellation, if the identified level in the table closest to the partial result is inside the basic constellation.

61. (new) The apparatus according to claim 59, wherein the output block includes a summer for adding the partial result and a mapping distance signal, wherein the mapping distance signal equals the distance between the index `basic_const`, associated with the basic constellation level of the input signal, and the index `positive_const`, associated with a level outside the basic constellation.

62. (new) The apparatus according to claim 49 wherein successive levels in the basic constellation are separated by a distance D1, and wherein a plurality of successive levels outside the basic constellation are separated by a distance D2 such that D1 differs from D2.

63. (new) The apparatus according to claim 49 wherein a plurality of index values are associated, respectively, with a plurality of amplitude levels in the constellation of levels.

64. (new) The precoder according to claim 1 wherein a plurality of index values are associated, respectively, with a plurality of amplitude levels in the constellation of levels.

65. (new) The precoder according to claim 18 wherein a plurality of index values are associated, respectively, with a plurality of amplitude levels in the constellation of levels.

66. (new) The method of precoding according to claim 25 wherein a plurality of index values are associated, respectively, with a plurality of amplitude levels in the constellation of levels.

67. (new) The computer-readable medium of claim 39 wherein a plurality of index values are associated, respectively, with a plurality of amplitude levels in the constellation of levels.

**IN THE DRAWINGS:**

The attached four sheets of drawings replace the existing drawings with formal FIGURES 1-6. No changes have been made to FIGURES 1-6 on the replacement sheets except curing of the informalities that have been noted.

Attachment: Replacement sheets 1-4